Patterns and Scales of Variability in the Optical Properties of Georges Bank Waters, with Special Reference to Phytoplankton Biomass and Production

Heidi M. Sosik
Biology Department, MS 32
Woods Hole Oceanographic Institution
Woods Hole, MA 02534-1049
phone: (508) 289-2311 fax: (508) 457-2134 email: hsosik@whoi.edu
Award #: N000149710646

LONG TERM GOALS

The long term goals of this work are to contribute to a fundamental understanding of the sources of optical variability in coastal ocean systems. Particular focus is on applications useful for studying important ecological processes and the links between phytoplankton properties and physical processes in coastal regions.

OBJECTIVES

The initial objectives of this project are focused on making measurements of time series and spatial distributions of both apparent and inherent optical properties in the waters of Georges Bank and the Gulf of Maine. These observations are being used to describe spatial and temporal patterns of variability and identify the dominant sources of variability in optical and phytoplankton properties in the region.

APPROACH

The approach we are pursuing is to integrate and deploy commercially available spectral radiance, irradiance, absorption and scattering sensors on existing oceanographic platforms with widely different spatial and temporal sampling regimes. Two platforms are being specifically adapted, a profiling oceanographic mooring and a towed underwater vehicle. In coordination with the GLOBEC Georges Bank study, these sampling platforms will be used to construct an observational data set for the waters on and around the bank, with temporal scales spanning hours to seasons and spatial scales of meters to hundreds of kilometers. This will be accomplished by combining measurements conducted from the mooring and towed vehicle with remotely sensed surface ocean optical properties from global ocean color missions (e.g., SeaWiFS) and with conventional ship-based sampling.

WORK COMPLETED

BIOMAPER II – Adaptation and integration of sensors into the BIOMAPER II (Bio-Optical Multifrequency Acoustical and Physical Environmental Recorder) towed vehicle has been fully completed and successful observations have begun (Fig. 1). BIOMAPER II, designed and built at the Woods Hole Oceanographic Institution primarily for acoustic research (Wiebe et al. 1997), now routinely carries two spectral radiometers (OCI/OCR-200 series, Satlantic, Inc.) and

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two ac-9 in situ absorption and attenuation meters (Wet Labs, Inc.), one sampling whole water and the other sampling material less than 0.2 μm (see Sosik et al. 1998, last year's report, and http://www.whoi.edu/science/B/sosiklab/onryip.htm for more details). The upgraded vehicle also

Figure 1. Deployment of the upgraded BIOMAPER II towed vehicle during a GLOBEC cruise in the Gulf of Maine (R/V Endeavor 307, October 1997). The downwelling irradiance sensor is visible on top of the vehicle tail and the aluminum frame that supports the upwelling radiance sensor is partly visible in the lower right corner of the image. The ac-9 sensors and associated pumps are enclosed in the vehicle body, with inlet tubes for water flow projecting from the right side of the vehicle. A single wavelength transmissometer and upward-looking acoustic transducers are visible on the top mid-section of the vehicle and the VPR is mounted on the nose, just forward of the weight-bearing harness and fiber optic connection. Computer systems for instrument control, power and data handling are all enclosed in the vehicle body.

now carries a Video Plankton Recorder (VPR) designed to observe plankton of mm size or larger. On recent GLOBEC program cruises to the Gulf of Maine and Georges Bank (R/V Endeavor cruise #307, October 8-17, 1997 and R/V Oceanus cruise # 332, October 19-30, 1998), the new vehicle configuration and optical sensor acquisition system were successfully used to collect observations nearly continuously throughout the water column. During these cruises, BIOMAPER II was towed behind the ship and manually controlled (based on ship speed and winch operation) to produce "tow-yo" flight patterns.

AVPPO – We have also recently completed adaptation and integration of sensors into the Autonomous Vertically Profiling Plankton Observatory (AVPPO). AVPPO is a mooring system

for operation in coastal environments, designed and constructed at the Woods Hole Oceanographic Institution (Gallager et al. 1998, Thwaites et al. 1998). The AVPPO consists of a combination of a buoyant sampling vehicle and a trawl-resistant bottom-mounted enclosure, which holds a winch, the vehicle (when not sampling) and batteries. The AVPPO is set to sample at preprogrammed times; the vehicle is released and floats to the surface, with power and data connection maintained through the winch cable, and is then returned to the bottom with the winch. High-resolution vertical sampling can be conducted on the up- and/or downward profiles and on scales of minutes to weeks and months, limited by power and data capacities. The primary sampling system on the original vehicle is a dual camera VPR, but it also carries accessory environmental sensors (including conductivity, temperature, pressure, chlorophyll fluorescence and beam transmission). As part of this project, we have integrated the same suite of optical sensors as on BIOMAPER II (except with only one ac-9) into the AVPPO sampling vehicle (Fig. 2). The new optical sensor data acquisition system includes power and network connections to the main vehicle systems and on-board data storage (Fig. 3).

The new AVPPO configuration has been tested using both shore link and autonomous modes in waters off Woods Hole, MA. Hydrographic, optical and video data were successfully recorded during hourly profiles over periods from days to 1-2 weeks. Following further testing, an approximately 3-month deployment on Georges Bank is planned for later this year. This deployment will coincide with collection of SeaWiFS ocean color imagery and will encompass a planned BIOMAPER II survey cruise (December 1-13, 1998).

SeaWiFS – In conjunction with the current and planned BIOMAPER II and AVPPO sampling, we have begun processing and interpretation of SeaWiFS ocean color images for the Georges Bank/Gulf of Maine region. On the most recent BIOMAPER II cruise, imagery was used to guide observations and sampling strategy ensuring that a variety of optical water types were surveyed.

RESULTS

New Observations from BIOMAPER II were collected too recently (October 19-30, 1998) to be available at this time. Preliminary analysis of results at sea, however, confirm that excellent data was collected and a variety of water types were sampled, including relatively high pigment (3-5 mg m^{-3}) shallow waters (50-70 m) on and around Georges Bank and stratified waters of the deep (200-300 m) basins in the Gulf of Maine.

The AVPPO system has been successfully tested in autonomous mode in waters off Woods Hole. High quality optical data were collected with the ac-9 and the radiometers. With hourly sampling, diel changes and trends over several days were evident in both hydrographic and optical properties (Fig. 3).

IMPACT/APPLICATIONS

This research will contribute to a fundamental understanding of the sources of optical variability in coastal ocean systems. This in turn has implications for better understanding of ecological processes in these regions, since there are strong connections between optical characteristics and plant biomass and primary production. These connections span scales from single cells to the global ecosystem and optical techniques provide the potential for measurements that cover this range. This work will also contribute to the development of approaches and methods for merging information from widely different observational perspectives to obtain consistent and unbiased views of how large natural systems function. We anticipate that complementary spatial and temporal information will contribute to better understanding of the sources and mechanisms leading to optical variability in an important region of the coastal ocean.

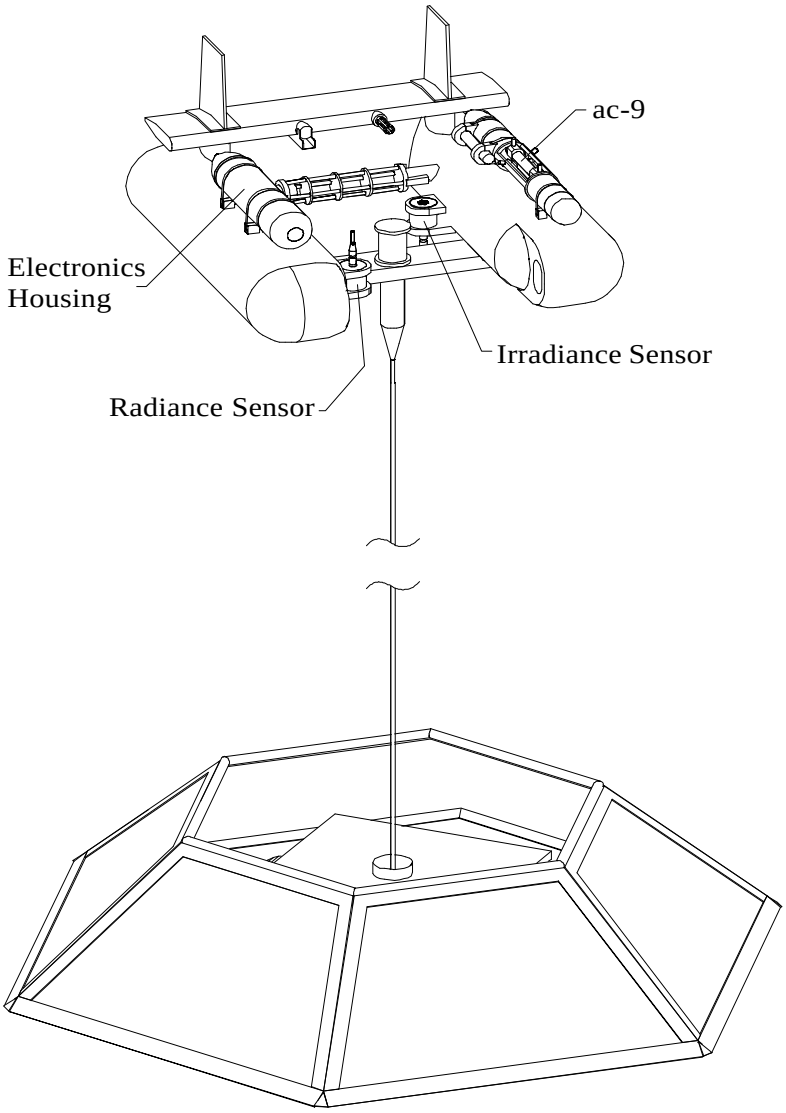

Figure 2. View of the upgraded AVPPO showing the optical sensor system integrated into the profiling vehicle. The ac-9 and optical system electronics case are mounted on top of the vehicle body and the up- and down-looking radiometers heads are positioned on the insides edges for protection during landing. CTD sensors and a single wavelength transmissometer are also visible on the vehicle; the VPR sensing system is housed in the nose of the vehicle. The winch in the bottom-mounted housing is not visible.

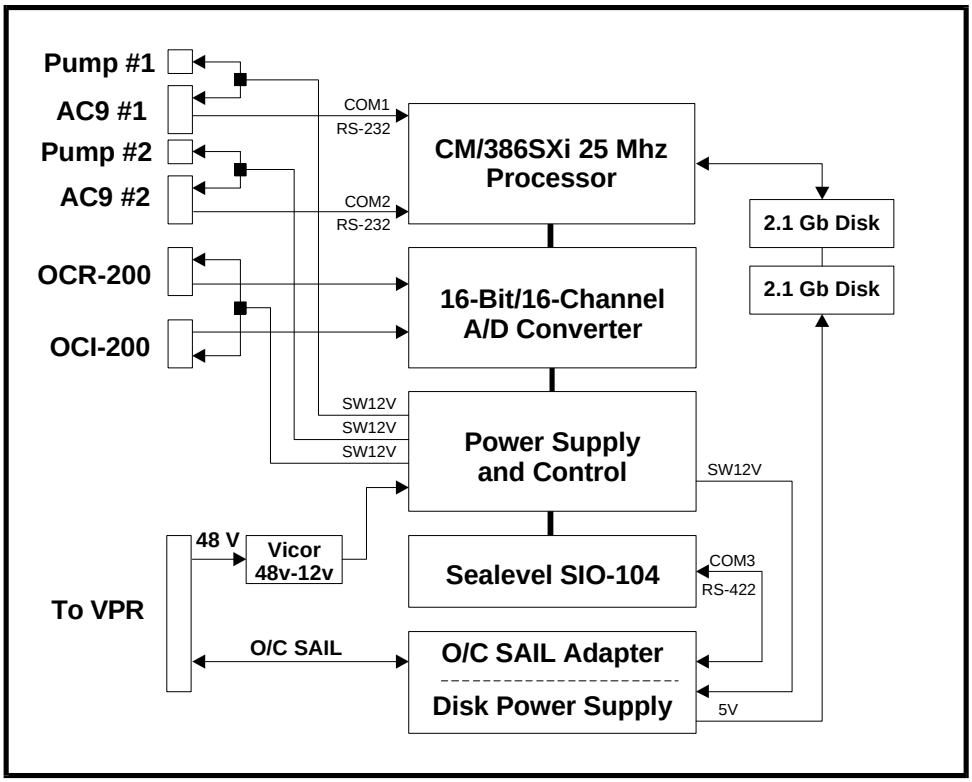

Figure 3. Block diagram of the acquisition system for the optical sensors integrated into AVPPO. The data acquisition system (designed and assembled at WHOI) for these instruments is based on a subsurface PC-104 and includes 2 serial ports, a 16-channel/16-bit A/D converter, two 2-Gb hard disks and an open collector SAIL network adapter for communication with the AVPPO main network. This system enables storage of data files on redundant hard drives on board the profiling vehicle. Download is achieved post-deployment by ftp protocol after connecting a temporary Ethernet adapter in the laboratory.

TRANSITIONS

Currently we have exchanged preliminary results from the BIOMAPER II cruises with investigators conducting acoustic research using the vehicle (P. Wiebe, WHOI & C. Greene, Cornell U.). This includes recent exchange of ideas and data for three-dimensional visualization of the towed vehicle observations. Transitions from the AVPPO work will depend on future deployments of the vehicle on Georges Bank.

RELATED PROJECTS

Observational work with BIOMAPER II in the Gulf of Maine and Georges Bank is dependent on close collaboration with a GLOBEC program project (NOAA, C. Greene, M. Benfield and P. Wiebe). We have a similar collaboration with an ongoing project supporting

development of the AVPPO (NSF, S. Gallager and C. Davis). Finally, recently initiated NASA-supported work in our laboratory (H. Sosik and L. Martin Traykovski) is closely related to this project. The NASA work is aimed at developing classification methods for optical water types based on remotely-sensed ocean color imagery of the northwest Atlantic; it will take advantage of in situ observations collected as part of this project and will contribute valuable interpretation of remote sensing results.

REFERENCES

Gallager, S. M., F. T. Thwaites, C. S. Davis, A. M. Bradley and A. Girard. 1998. Time series measurements in the coastal ocean: The Autonomous Vertically Profiling Plankton Observatory (AVPPO). Sea Technology. Submitted.

Martin Traykovski L. V. and H. M. Sosik. 1998. Optical classification of water types based on ocean color. In: Ocean Optics XIV, S. G. Ackleson (ed.). In press.

Sosik, H. M., R. E. Green and R. J. Olson. 1998. Optical variability in coastal waters of the Northwest Atlantic. In: Ocean Optics XIV, S. G. Ackleson (ed.). In press.

Thwaites F. T., S. M. Gallager, C. S. Davis, A. M. Bradley, A. Girard and W. Paul. 1998. A winch and cable for the autonomous vertically profiling plankton observatory. Proc. "Oceans 98". In press.

Wiebe, P. H, T. K. Stanton, M. C. Benfield, D. Mountain and C. H. Greene. 1997. Acoustical study of the spatial distribution of plankton on Georges Bank and the relationship between volume backscattering strength and the taxonomic composition of the plankton. IEEE J. Oceanic Eng. 22: 445-464.

Web Sites:

http://www.whoi.edu/science/B/sosiklab/onryip.htm

http://seal.whoi.edu

http://globec.whoi.edu

specifically: http://globec.whoi.edu/images/gb/bmapcombo.html

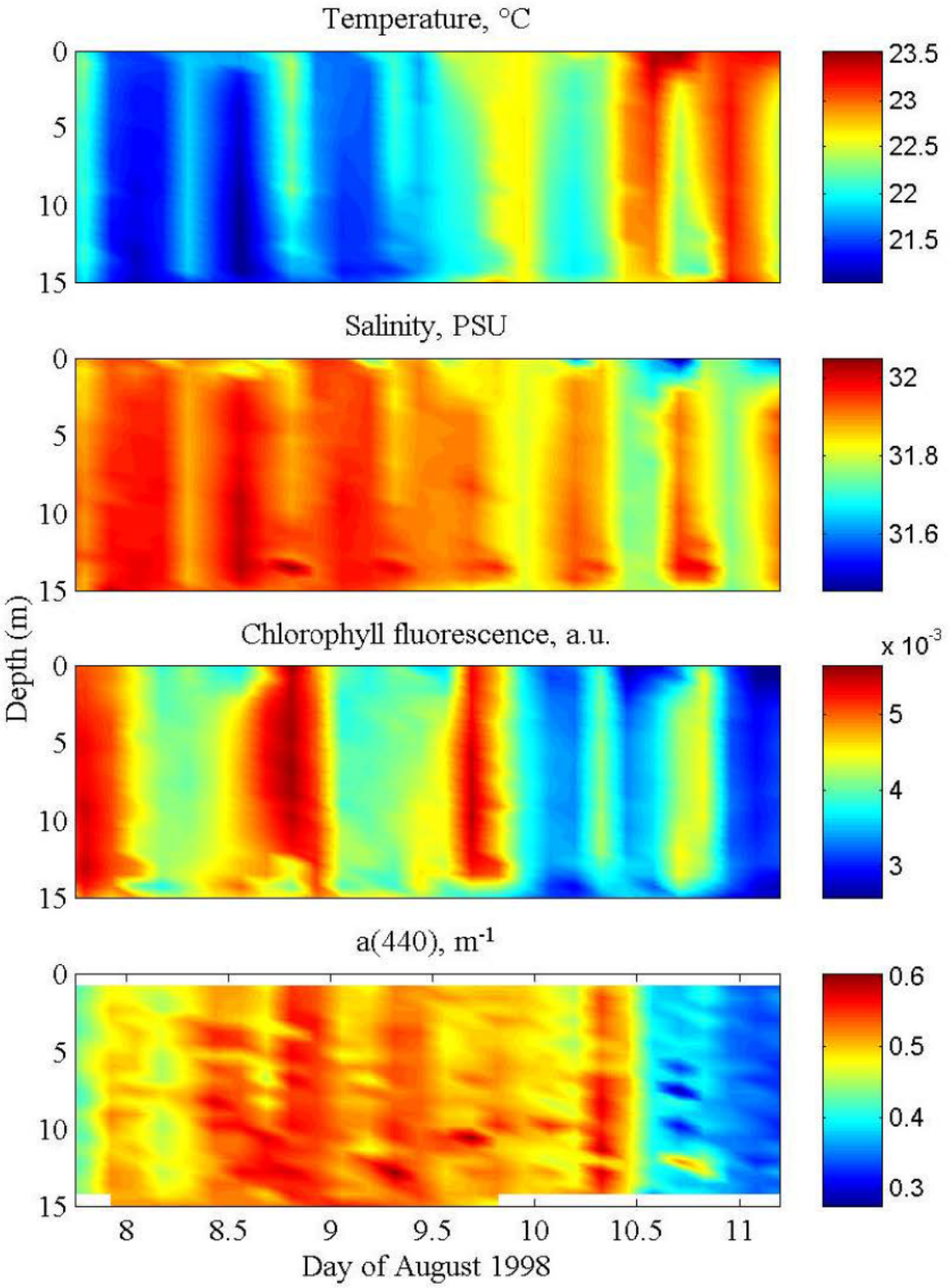

Figure 4. Time series of hydrographic and optical properties collected from the AVPPO mooring during autonomous profiling tests off Woods Hole, MA. Hourly vertical profiles allowed diurnal, tidal and weekly variations to be observed.